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(54) Abstract Title

Manufacture of friction elements

(57) A method of manufacturing a sheet of friction material for an automobile brake shoe, and apparatus therefor, includes forming a plastic lining element of uncured or green thermosetting resin binder containing friction modifiers and fibrous reinforcements and curing the resin binder in a defined heat and pressure regime which cures the resin binder by cross-linking and produces a sheet of defined dimensions and whose major faces are not disrupted by gases evolved during the curing. The need for a closed mould and/or venting stops is avoided by use of a stabilising press (50, Fig 3(a)) which includes a heated bed 52 between guide plates 56, 57 to receive such lining element in its green state. The guide plates are spaced slightly further apart than the width of a closure member 53 which is, having been pre-heated, brought down onto the lining element and pressed by a pn umatic ram 70, the loosely sliding closure member comprising a non-sealing closure of the press. The previously heated surface 52 of press bed and closure member 53 combine with the lightly ramped-up pressure to create setting-up of the surface resins and fix final dimensions; the ram position is then clamped to permit internal pressure growth as curing proceeds and gases are vented without disrupting the sealed major surfaces. After less than 1 minute the lining element sheet is sufficiently cured and dimensionally stable to be taken from the press and baked unconstrained to effect final cure.

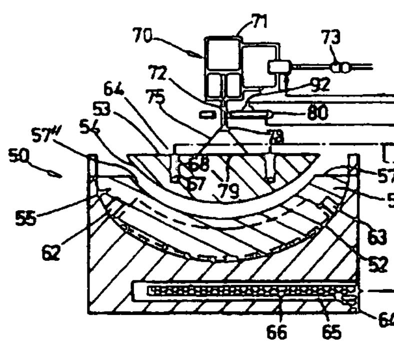

Fig. 3(a)

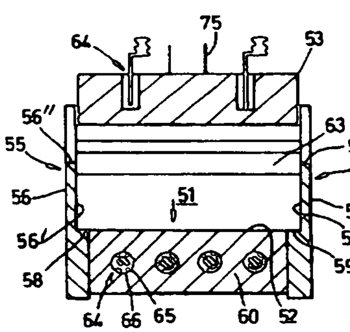

Fig. 3(b)

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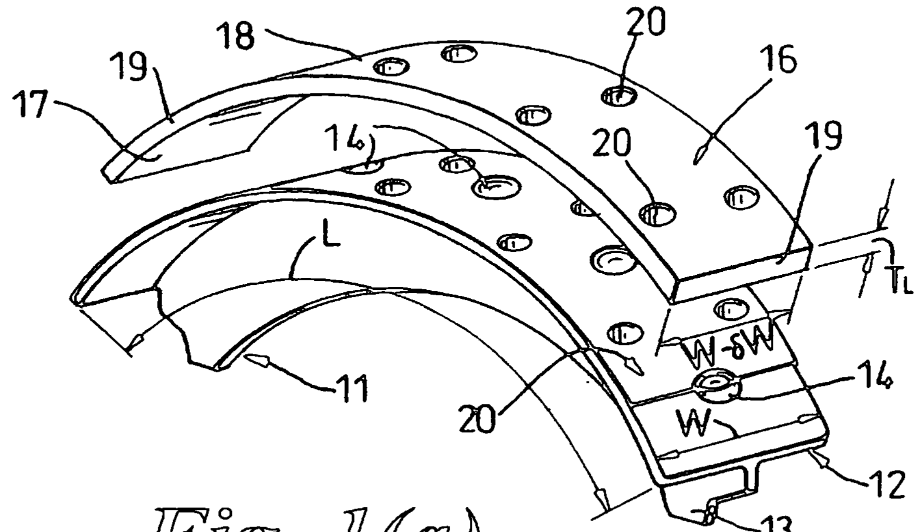

Fig. 1(a)

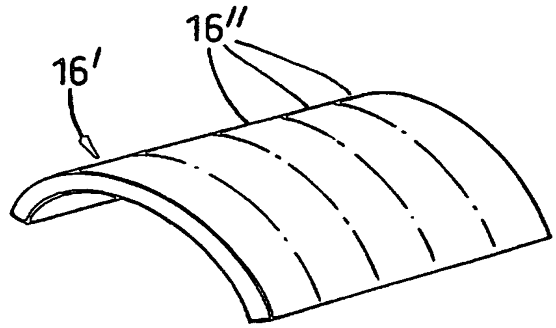

Fig. 1(b)

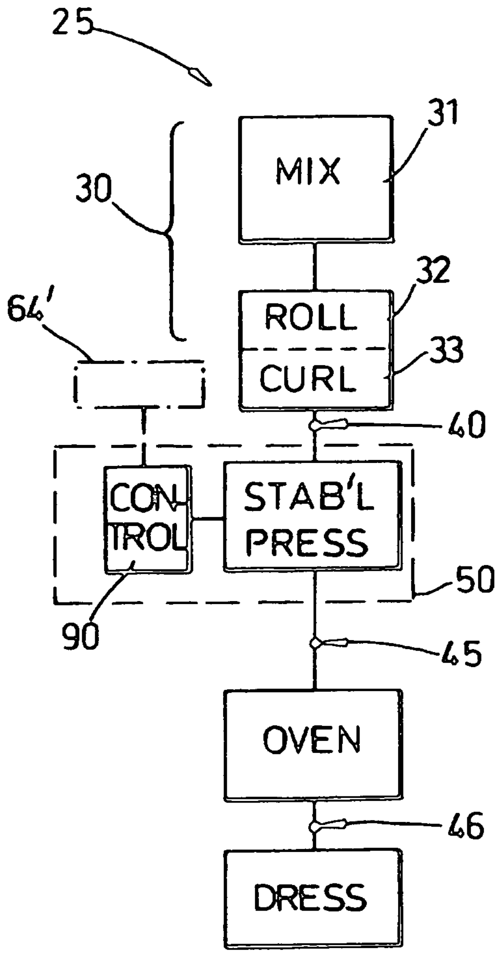

Fig. 2(a)

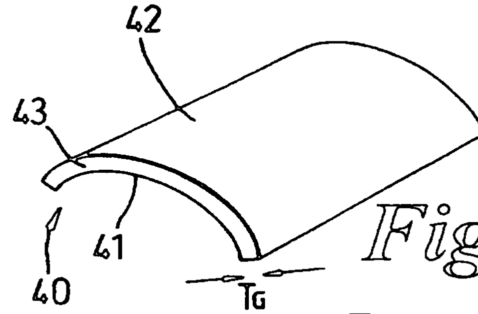

Fig. 2(b)

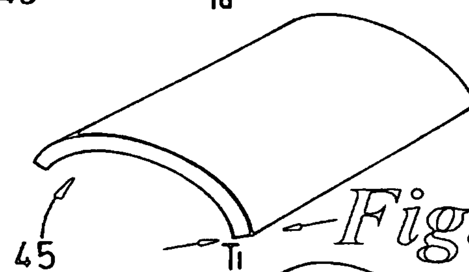

Fig. 2(c)

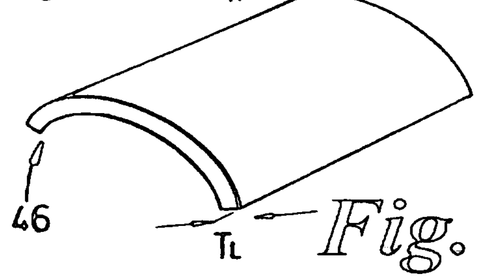

Fig. 2(d)

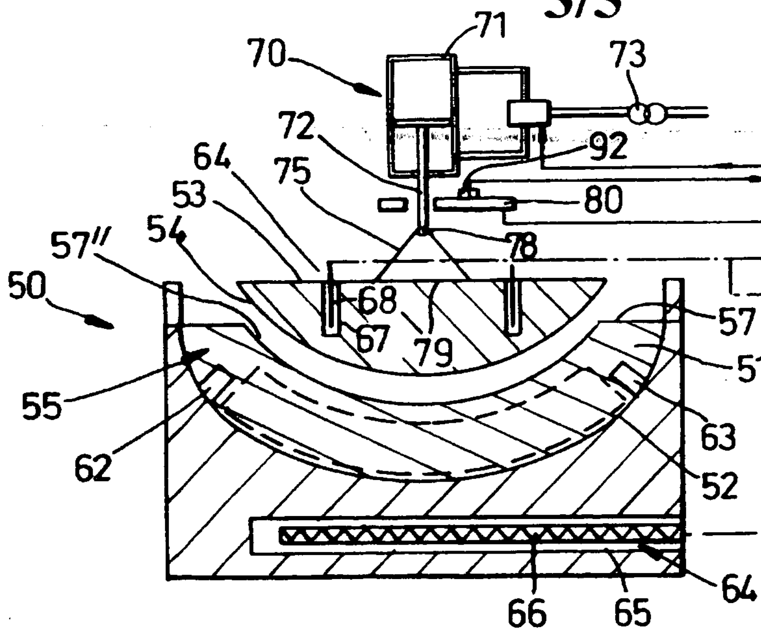

Fig. 3(a)

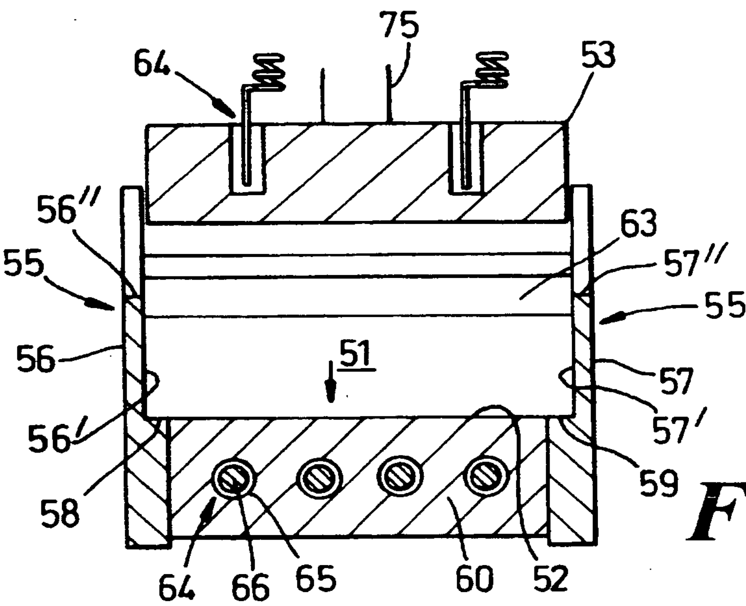

Fig. 3(b)

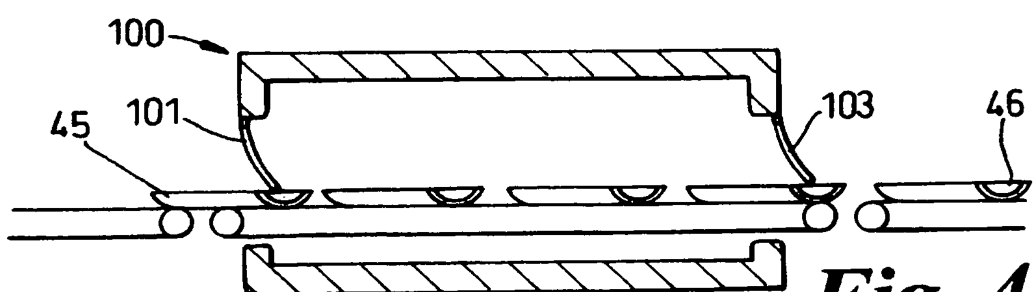

Fig 4

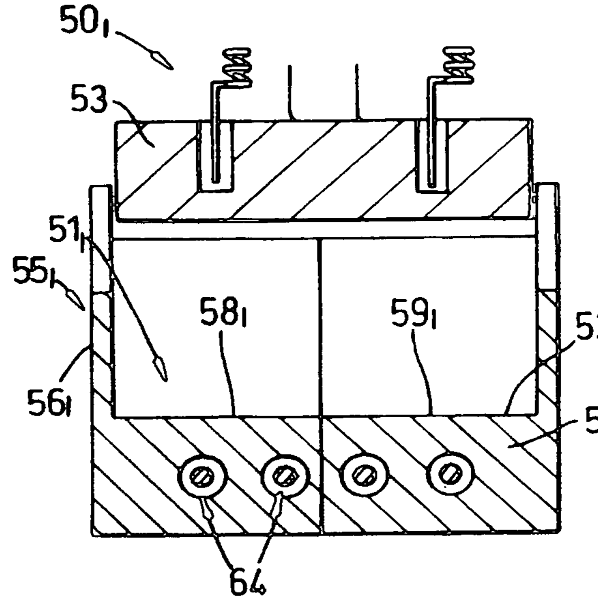

Fig. 5(a)

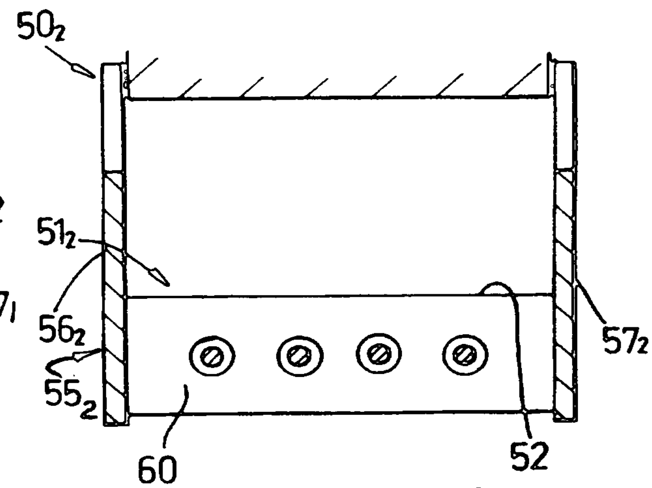

Fig. 5(b)

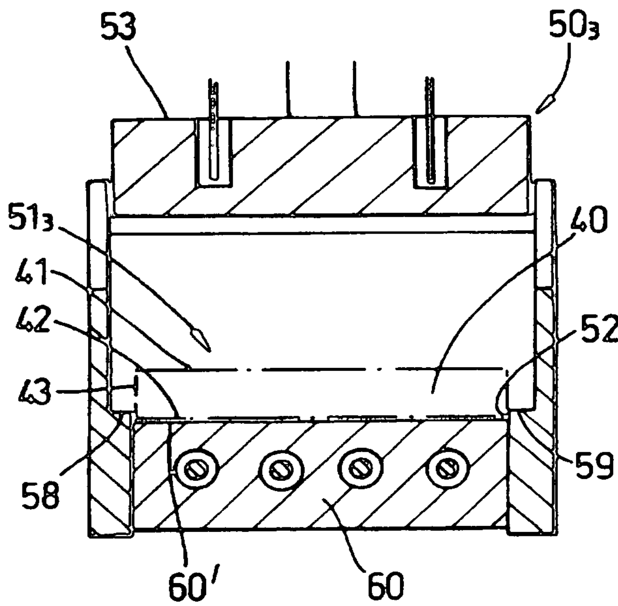

Fig. 5(c)

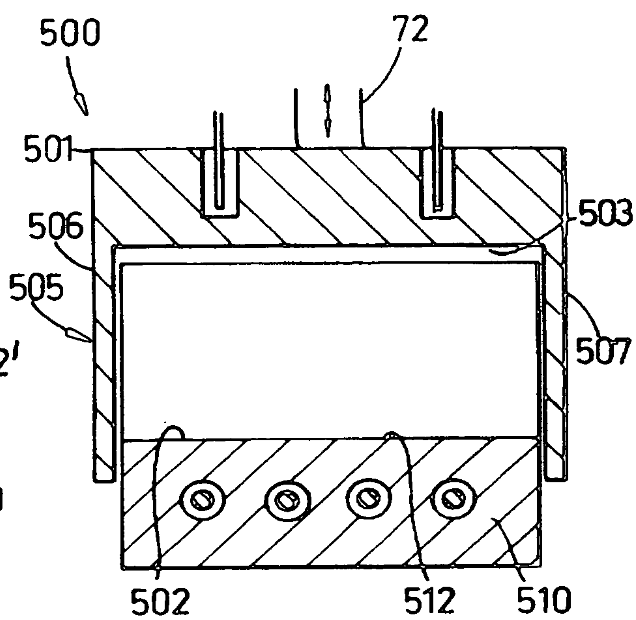

Fig. 5(d)

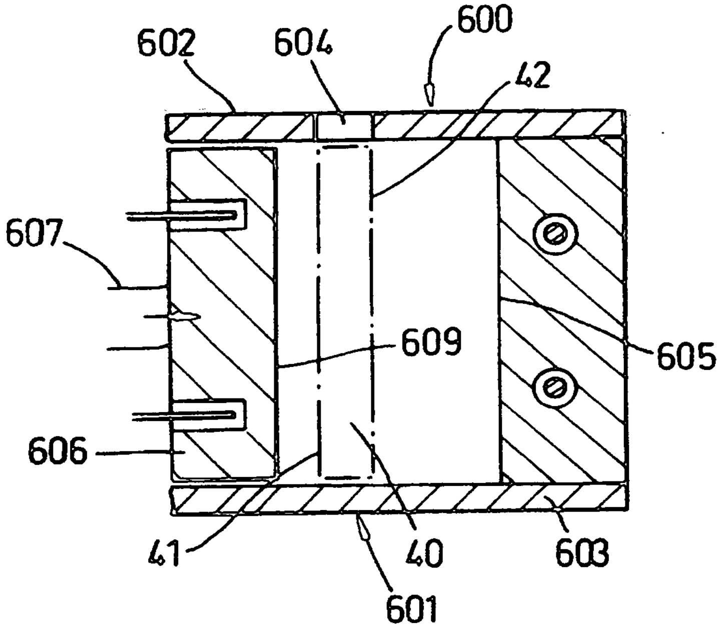
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Fig. 6

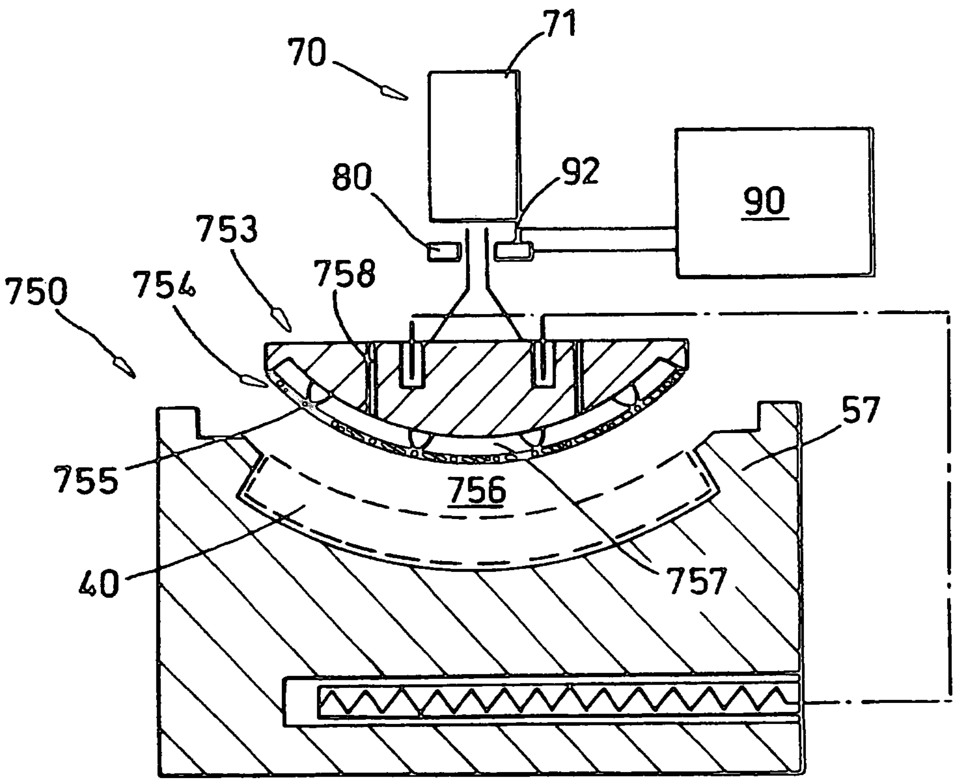
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Fig. 7

Manufacture of Thermoset Products

This invention relates to products formed and defined by thermoset resin, such as friction linings for friction elements such as brake shoes or clutch plates, and in particular relates to the manufacture of such friction linings.

The invention is particularly, but not exclusively, applicable to friction linings for brake shoes of the cylindrically arcuate drum type wherein the shoe structure comprises a cylindrically arcuate platform, on which a correspondingly arcuate lining is carried, and a transverse supporting web. It is however also applicable to friction linings for brake shoes of the generally flat, disc type and to similar flat friction linings used within a clutch arrangement.

Friction linings are commonly produced from a mixture of fibrous and/or filamentary reinforcement materials and friction modifying materials in a complex copolymer matrix of thermosetting resin and nitrile rubber as a binder, the mixture initially being rolled at or near ambient temperature into slabs or sheets, often having an area corresponding to a plurality of lining elements to be eventually cut therefrom. The so-called green lining sheet, that is, of which the thermosetting materials have not begun any cross-linking, is plastic and may be subject to a curling, or so-called radius-rolling, operation to give it a curvature in one cylindrical plane if intended to be used with an arcuate brake shoe.

In such known process, the green lining sheet is clamped to preserve or redefine its thickness and subjected to a resin curing operation, that is, a heating regime which initiates cross-linking of the thermosetting components, accompanied by setting-up, or reduction in plasticity, that results from the cross-linking. The sheet emerges from the regime as a non-plastic, and often substantially rigid, sheet having the appropriate degree of hardness and strength required of the friction lining, both for a frictional operation and to permit it to be handled and machined to the desired dimensions (and possibly curvature) cut into individual linings, and secured to a carrier to make the friction element.

In respect of making such cylindrically arcuate lining sheets employed for brake shoes, it has

been typical to optimise resources by combining a l ngthy curing time with simultaneous curing of a large number of sheets.

To this end, each arcuate green lining sheet is disposed in a similarly arcuate, rigid carrier formed of cast iron or steel with another carrier (also carrying a lining sheet) supported thereon to sandwich the lining sheet, a stack of such carriers being subjected to a constant and relatively low pressure of about 87 kN/m^2 (12 psi). A plurality of stacks are assembled and then placed in the preheated oven where they are heated slowly to avoid the necessity for periodic disassembly and, if binder resin requires, venting to maintain sheet integrity during the heating and cross-linking, upon attendant generation of internal gases and pressures resulting therefrom, and after a predetermined interval are removed from the oven and cooled to facilitate further handling and processing.

It will be appreciated that such a traditional batch processing arrangement represents a compromise between simplicity of the process and extravagant resource usage that has several drawbacks that may be less suited to modern energy usage and plant investment.

For instance, each stack of carriers and green lining sheets that is assembled at ambient temperature and placed into the oven has a significant thermal mass so that a plurality of such stacks requires a significant heat input and time to raise the temperature thereof and initiate resin cross-linking within the lining sheets, and account for a significant part of the duration of the baking process and of the energy consumed by the oven in that time. However, because it is in the interests of the curing process that an initially slow and uniform rise in temperature is achieved that avoids venting stops, this absorption of heat by the relatively cold stacks achieves the desired process parameters. Furthermore, to achieve a significant manufacturing throughput, the oven requires to have a capacity to accept and heat a number of stacks simultaneously. The carriers, after removal from the oven have to be cooled, or permitted to cool, to ambient temperature before further use, that is, a significant proportion of the oven energy is expended in raising the temperature of the large number of carriers, and which energy is subsequently wasted by their cooling.

Typically, a baking operation of some 8 stacks, each of 15-20 sheets, requires some 5 hours in an oven heated to 240-300°C, th subsequent cooling taking additional time and/or resources.

Notwithstanding the energy consumption, it will also be appreciated that for each size and

shape (curvature) of green lining sheet a sufficient number of carriers is required to complete at least one load of the baking oven, that is, a significant investment is required in the carriers as well as oven energy consumption for the baking operation.

Preserving the generality of the foregoing as to the shape of the lining sheet, it is an object of the present invention to provide a method of manufacture, and a manufacturing arrangement, by which such sheets of friction lining can be manufactured more quickly and with less plant investment than hitherto.

According to a first aspect of the present invention a method of manufacturing a friction lining comprises (1) producing a plastic, green friction lining sheet, including fibrous and/or filamentary reinforcement and friction modifying materials in an uncured thermosetting binder matrix, below a setting-up temperature required to initiate cross-linking of the binder matrix and disposed between opposite major faces defining the sheet thickness, (2) disposing the green lining sheet in a stabilising press, having a bed conforming substantially to the shape and dimensions required of a major face of the lining sheet, sandwiching it between the bed and a non-sealing closure member, corresponding to the shape required of the opposite major face of the lining sheet, at least one of said bed and closure member being heated to a temperature in excess of said setting-up temperature, (3) applying to the sandwiched green lining sheet, by way of the closure member and bed, a consolidating pressure increasing over a predetermined consolidation interval from substantially zero to a predetermined level permitting plastic flow of the sheet into conformity with the recessed bed and closure member but without significant extrusion before onset of cross-linking of the thermosetting resin binder, and thereafter maintaining the separation between member and bed achieved at the end of the consolidation interval for a setting-up interval to permit cross-linking adjacent the heated surfaces to define a partially cured, dimensionally stabilised intermediate lining sheet having the final dimensions of the lining, (4) removing the bonded intermediate lining sheet from the stabilising press and (5) baking the intermediate lining sheet unconstrained at a predetermined baking temperature in excess of said setting-up temperature and for a baking interval to effect further curing of the thermosetting resin of the dimensionally defined lining sheet to a predetermined level of hardness and strength.

According to a second aspect of the present invention an arrangement for producing a friction lining, comprising fibrous and/or filamentary reinforcement and friction modifying materials in a thermosetting binder matrix between one major face of the element and an opposite one

defining its thickness, comprises

a) formulating means, operable to produce a green friction lining sheet, in which the thermosetting binder matrix is uncured and below a setting-up temperature at which cross-linking thereof is initiated, b) a stabilising press including1) a bed shaped substantially corresponding to the profile required of said one face of the lining sheet and dimensioned to receive a said green lining sheet with said one major face thereof against the bed, 2) a non-sealing closure member having a closure face corresponding to the sheet required of the opposite major face of the lining sheet, 3) guidance means extending away from the bed and operable to support said closure member overlying the bed with the closure face directed thereto and effect guidance between the closure member and the bed in a direction towards and away from the bed, 4) heating means operable to heat at least one of the bed and the closure member to above said setting-up temperature for the lining element, 5) ram means, having relatively displaceable parts fixed and movable respectively with respect to the bed, operable to drive the closure member and bed towards each other, 6) locking means operabl to retain the closure member in position with respect to the bed, and 7) control means operable (i) to cause the ram means to move the closure member to sandwich the green friction lining sheet between the closure face and the bed, (ii) to cause the ram means to apply a force between the closure member and bed increasing between predetermined levels in a predetermined consolidating interval, sufficient to force the materials of the lining sheet into conformity with the closure member and bed without significant extrusion of unconfined materials, prior to significant cross-linking of the thermosetting binder matrix due to heat and pressure applied to the surface regions, (iii) to initiate operation of the locking means to lock the closure member in position with respect to the bed at the end of said consolidating interval for a setting-up interval in which said surface regions achieve by continued cross-linking structural strength in excess of internally generated forces resulting from the cross-linking and heating, and (iv) to initiate release of the locking means at the end of said setting-up interval to permit the intermediate lining sheet of partially cured, dimensionally stable friction lining material to be removed from the press, and c) oven means operable to receive said intermediate lining sheet unconfined at a predetermined baking temperature in excess of said setting-up temperature for a predetermined baking interval to effect additional cross-linking of the thermosetting components thereof to cure the friction lining to a predefined condition of hardness and physical strength.

Embodiments of the invention will now be d scribed by way of xample with reference to the accompanying drawings, in which:-

Figure 1(a) is a perspective view of components employed in relation to a friction element comprising a brake shoe illustrating relative dimensions and juxtapositions of a shoe body having a cylindrically arcuate platform and a substantially correspondingly arcuate friction lining dressed, that is, machined, drilled and trimmed to size, for attachment thereto,

Figure 1(b) is a perspective view of an arcuate dressed friction lining sheet prior to cutting into a plurality of the linings of Figure 1(a),

Figure 2(a) is a flow chart showing schematically the operational steps in manufacturing an arcuate friction lining in accordance with the present invention and indicating the apparatus for performing specific operations including a stabilising press for producing a partially cured, intermediate lining sheet and an oven for baking the intermediate lining sheet to complete curing unconstrained,

Figures 2(b) to 2(c) are perspective views, similar to Figure 1(b) of the friction lining sheet at various stages of resin cure, being green, intermediate and undressed lining sheets respectively,

Figure 3(a) is a sectional elevation through the stabilising press indicated in Figure 2, showing a recessed heated bed dimensioned and profiled to receive an arcuate green lining sheet and a heated closure member, ram means to apply sandwiching pressure to the sheet by way of the closure member, and control means to monitor and control the level and duration of pressure to provide a dimensionally stable, partially cured, intermediate lining sheet,

Figure 3(b) is a sectional elevation through the stabilising press taken at right angles to Figure 3(a), showing the guidance means defined by spaced guidance plates and separated by a thermally conductive metal block defining the recessed bed of the press,

Figure 4 is a schematic sectional elevation of continuous oven means for baking the bonded intermediate lining sheet to a further degree of cure on an unconstrained form and on a continuous basis, and

Figures 5(a) to 5(c) are sectional elevations, generally similar to Figure 3(b) of alternative detailed forms of press bed,

Figure 5(d) is a sectional elevation, similar to Figure 5(b) but showing the inversion of relationship between guidance means, press bed and closure member,

Figure 6 is a sectional elevation of an alternative form of stabilising press in which the green lining sheet is introduced vertically and sandwiching pressure applied horizontally, and

Figure 7 is a sectional elevation, similar to that of Figure 3(a), through a separate embodiment of stabilising press in which the closure member includes an array of small vent apertures communicating with the atmosphere whereby the lining element can vent directly from the major face thereof that is pressed by the closure member.

Referring to Figure 1, the component parts of a friction element in the form of a brake shoe of the type used in a drum brake are shown. A shoe body 11 is formed of steel and comprises a cylindrically curved platform 12, which forms a section of a notional right circular cylinder having an arc length L in the direction of curvature and being substantially flat of width W in a transverse direction parallel to the longitudinal axis of the notional cylinder defining the curvature, and a substantially planar bracing web 13, which extends perpendicularly to the platform as a central spine and to the edge of which web the platform is welded at intervals along its length to define the curvature. The shoe body is conventional in structure and may conform with conventional variants, such as the platform being divided along its length and assembled from two "half-platforms" welded to the web.

In addition to the shoe body the components include a friction lining element 16. The lining element is conventional in including friction modifying materials and reinforcement fibre and/or filaments in a complex thermosetting copolymer matrix of a thermosetting resin and nitrile rubber as a binder.

The lining element is dimensionally fixed due to cross-linking and curing of the thermosetting resin binder at elevated temperature and pressure, the precise values of which determines the frictional and physical parameters of the lining.

The cured lining having so-called final dim nsions, that is, the dimensions at the nd of the curing phase, is dressed, that is, cut, ground and otherwise machined or drilled to impart precise size and degree of curvature to the major faces 17, 18, thickness T_L to minor faces 19

and fixing holes 20, all of which are known in the art.

It is also known for such a dressed lining to be produced initially as a larger sheet 16', as shown in Figure 1(b), from which individual linings are cut, as indicated by broken lines 16". Clearly any face machining and/or drilling can be carried out on the lining sheet prior to it being cut into individual linings.

The present invention principally concerns the manufacture of a lining sheet having properties and dimensions suitable to such dressing and provision of several linings 16, but it will be understood that a lining sheet may be manufactured substantially of the lining dimensions required for a single shoe.

Referring now to Figure 2(a), which is a flow chart indicating both the processes or operational steps that form the manufacture of a friction lining sheet of such thickness and curvature as to serve as a dynamic, or server, drum brake of a medium sized (1 tonne gross, 2 litre engine) passenger automobile or parking brake of a similar or larger vehicle and, where appropriate, specific apparatus for performing those processes, and to Figures 2(b) to 2(d) which illustrate the products of such steps, a friction material is produced in conventional manner in formulating means (30) by admixing (31) the above described ingredients, with the rubber as a fine powder in which the molecular chains have been reduced mechanically so that it is able to combine chemically with the resin used in liquid form, to give the binder a handleable plastic consistency and suited to rolling (32) substantially at ambient temperature to define with the friction modifying and reinforcement ingredients a so-called green lining sheet 40, Figure 2(b), of predetermined density D_G and dispose the fibrous materials in alignment with major faces 41, 42, bounded by minor faces 43, that define its rolled thickness T_G. For a lining element having the dimensions for this class of brake a lining thickness T_L of about 4.5mm and a green thickness of T_G of 6mm or less is to be expected. The rolling also includes a curling, or radius-rolling, step (33) whereby the lining sheet is passed between rollers running at different speeds and assumes a generally cylindrical curvature corresponding approximately to the curvature of the brake shoe platform for which it is intended.

Depending upon the nature of the thermosetting resin binder, that is, whether or not its curing results in gases within the material, the density D_G of the green lining element sheet is typically 80%-95% of the density D_L required of the lining when the resin is cured and it is secured to the shoe platform, that is, $D_G=(D_L-\delta D_L)$. As is common in th art, the density required of the final

lining is l ss than the theoretical maximum density, typically of the order of 95%, so that the rolled material may have a density of 75%-90% of being fully densified.

Likewise, the rolled thickness T_G at this lower density is correspondingly greater than the desired final thickness T to allow the change in volume by way of minor changes in length and width and to produce said change δD in density by way of a reduction in thickness, that is $T_G = (T_L + \delta T_L)$.

The rolled, arcuate green lining sheet 40 is disposed in a stabilising press 50 such that one major face of the sheet rests on a heated bed of the press substantially conforming thereto in curvature and the opposite major face is abutted by a heated non-sealing closure member conforming substantially to the curvature of that face (as more fully described below), a sandwiching-pressure time regime is established which results, within a short interval typically less than one minute, in the thermosetting resins of the lining achieving sufficient degree of cross-linking and setting-up to give a dimensionally stabilised, partially cured, intermediate lining sheet, 45, Figure 2(c), that can be removed from the stabilising press and subjected unconfined to continued elevated temperature and resultant cross-linking of the resin by so called free-baking in oven means (100). The oven means is held at a temperature in the range 240-300°C and each intermediate lining sheet is disposed therein for about 20-60 minutes to achieve a degree of friction material curing typically required for a friction lining of a brake to give it the properties of hardness and mechanical strength required, resulting in a final, undressed, lining sheet 46, Figure 2(d), which has the physical properties and dimensions requiring only minor dressing operations to give the dressed lining sheet 16'.

It will be appreciated that the techniques and apparatus employed in the steps (31)-(33) with regard to the lining sheet are substantially conventional and they, and the collectively named formulating means 30 for effecting them, do not require describing or illustrating in greater detail.

Referring also to Figures 3(a) and 3(b), the stabilising press 50 associated with that operation step is dimensioned and shaped to produce the intermediate lining sheet 45 of Figure 2(c).

The press 50 comprises a recessed bed 51, the floor 52 of which is arcuate in on direction and has a curvature substantially corresponding to the radius of curvature required of the lining sheet and dimensioned to receive green lining sheet 40 with said convex major face 42 against

the floor.

A non-sealing closure member 53, having an arcuate closure face 54 that corresponds to the profile required of the opposite major face 41 of the lining sheet, is supported overlying the bed with the closure face 54 directed towards the bed by guidance means 55 arranged to effect guidance to relative motion between the closure member and the bed in a direction towards and away from the bed.

Structurally, the stabilising press 50 comprises a pair of spaced metal guidance plates 56, 57 spaced apart by the width of the closure member 53 such that it can slide freely between the facing surfaces 56' and 57' respectively thereof which define the guidance means 55 and without effecting any seal to gaseous products .

The plate 56 has a shoulder 58 extending from said facing surface 56' towards the facing plate 57 and likewise the plate 57 has a corresponding shoulder 59. The shoulders define the bed 51 of the press and are separated by a metal spacing block 60 which defines, and provides with the shoulders, the floor 52.

The shoulders 58 and 59 and the surface of the metal spacing block 60 are, of course, arcuate and define the part-cylindrical curvature of the bed of the press. The block 60 further comprises raised portions 62, 63 spaced apart in a direction parallel to the planes of the guidance plates and defining the ends of the recessed bed.

Heating means, indicated generally at 64, is operable to heat each of the bed and closure member, particularly the surface 52 of the bed and closure surface 54 of the closure member, to temperatures in excess of a so-called setting-up temperature required to initiate cross-linking of the green thermosetting resin binder. Typically a temperature in the range 210°C-250°C is sought, depending upon the precise thermosetting properties of the materials. The heating means comprises one or more apertures 65 in block 60, into each of which is inserted a heating element 66 to supply heat to the press bed 52 and maintain it at a desired temperature, and one or more apertures 67 in the closure member 53 into each of which is inserted a heating element 68.

The edges 56" and 57" respectively of the guidance plates remote from the shoulders that define the press bed are conveniently also arcuate to facilitate placing of the green lining sheet

between the guidance plates and against the bed.

The press 50 also includes ram means, indicated generally at 70, having parts displaceable relative to each other and fixed and movable respectively with respect to the bed 51. The ram means is operable to drive the closure member towards and away from the bed of the press. Conveniently the ram means comprises a simple pneumatic piston and cylinder arrangement 71 and a source 72 of pressurised fluid for the cylinder, to displace the piston with respect thereto, which is able to exert a limited maximum pressure only on the closure member, such pressure being low for a manufacture in this art, and of the order of 50-150 kN/m^2 (7-21.75 psi) for a lining sheet of this thickness.

The ram means further includes a ram interface 75 coupled to movable ram part 71 at 78 and to the closure member at 79, conveniently one or both couplings being pivoted.

Locking means, indicated schematically at 80, is operable to retain the closure member in position with respect to the bed when required and notwithstanding the level of any reaction or back pressure exerted on the ram means by the closure member.

The stabilising press further includes control means 90 which controls and co-ordinates many of the integers of the press described above such that it operates in accordance with a predetermined regime to produce the above-mentioned dimensionally stabilised, partially cured, intermediate lining sheet 45 of density D_I and thickness T_I.

The control means 90 is coupled to provide instruction signals to, and receive monitoring signals from, the ram means and locking means, in particular monitoring the reaction pressure imposed upon the locking means by pressure within the lining sheet The control means may also, for convenience, control the heating means 64.

Considering operation of the stabilising press in producing an intermediate lining sheet 45, closure member 53 and the bed of the press are heated by the elements 64 and 65 to th temperature defined by the control means. The recess floor 52 of the press and closure face 54 are treated with a mould rel ase agent (if th y do not have a permanent non-stick coating) and the arcuate green element 40 is disposed manually or by machine on the bed floor.

The pre-heated closure m mber is displaced between the guide plates 56, 57 by the ram

means and permitted to rest on the concave face 42 of the green lining sh et. At this time the lining sheet is, by way of its major faces 41 and 42, in receipt of heat transf rred from the press bed and closure member face and becomes, at least at the surface regions, relatively fluid or mobile.

The ram means is actuated by the control means such that the ram interface applies a sandwiching pressure which is increased from the initial, substantially zero, pressure for a predetermined consolidating interval to reach a said predetermined, but still relatively low, level. The instantaneous pressure level effects plastic flow of the green lining materials into conformity with the recessed bed 51 but, bearing in mind the absence of sealing between the closure member and guidance plates, is chosen to avoid any significant extrusion of the lining material between the closure member and guidance means before the onset of cross-linking and setting-up of the resin. Such consolidation of the more fluid material under pressure has an effect of reducing its thickness somewhat. After an initial heat-absorbing period in which the resin binder achieves this fluidity, cross-linking begins to occur which results in evolution of gasses and vapours within the matrix of the lining, including those trapped by the initial mixing and rolling, which are capable of leaving the element between the carrier and guidance plates. Such gases are helped out of the element by the increasing sandwiching pressure and the loss of these may result in a reduction of thickness from $T_G = (T_L+\delta T_L)$ to $T_I = (T_L+\delta_I T_L)$.

For an 'automobile size' of brake shoe friction element it has been found that increasing the pressure over a consolidating interval of approximately 4-6 seconds to a level within the range of 35-120 kN/m^2 (5-17 psi) is suitable and for a more extensive sheet, within the (range 50-150kN/m^2 (7-21.75 psi).

Furthermore, after only a few seconds that represents the consolidating interval the cross-linking of the thermosetting resin binder at the surface regions of the element in receipt of heat from the bed and closure member is sufficiently advanced that most of the initially present and evolved gases and vapours have been forced out as setting-up commences and the dimensions of the sheet are those applicable to the fully cured lining sheet, notwithstanding that the bulk of the lining material has not achieved such level of cross-linking and is still to undergo such process with its potentially attendant gas and vapour volution.

At the end of the aforementioned and predetermined consolidating interval, the control means actuates the locking means 80 which maintains the separation achieved between the closure

member and press bed for a further, setting-up period, typically about 45-120 seconds, to permit a further degree of cross-linking adjacent the heated surfaces and progressiv ly further within the bulk of the material. Notwithstanding that internal pressures are generated within the lining material by gases evolving during said cross-linking, which internal pressures react against the locking means, these gases are permitted to escape the boundaries whilst the locking means prevents the relatively fragile solidified major surface regions from being ruptured by these additional, but relatively short-lived, internal forces.

At the end of this setting-up period, the level of reaction subsides significantly so that notwithstanding the incomplete level of cross-linking within the resin binder, the lining element can be removed from constraint and remain dimensionally stable having achieved its final density D_I (=D_L) and thickness T_I.

The control means 90 monitors the pressure exerted by the curing lining sheet on the ram means and locking means throughout the consolidating and setting-up intervals; during the consolidating interval the pressure exerted by the ram is a measure of this and during the setting-up interval, the force exerted on the locking means by the sheet pressure is measured by a load cell 92, or the like.

It will be appreciated that effecting a rapid setting-up and partial cure that results in a dimensionally stable intermediate lining sheet is subject to a number of interrelated variables, such as lining material composition, dimensions, bed and closure member temperatures, applied consolidating pressure and rate.

It is found most practicable to undertake, for a particular friction lining material composition and final lining sheet size, experimental operation with various temperatures, consolidating pressure rate and interval and setting-up interval parameters which results in an intermediate lining sheet having the correct dimensions and density, that is, known to result in friction lining having the desired physical properties after said unconfined baking. Thereafter, and substantially reproduced the manufacture, the temperature, sandwiching pressure and time intervals are stored in the control means, or means coupled thereto, the reaction pressures from the lining sheet are monitored s a function of time throughout the consolidating and setting-up intervals and the monitored and stored param ters compared, it being possibl to determine with a considerable degree of certainty that the intermediate lining sheet is satisfactory or not; that is, whether or not it is to be accepted or declared a reject.

Most practicably, the temperature and pressures parameters are monitored by sampling at intervals and, if necessary, any parameter values at intermediate times interpolated from these. The values obtained at, or interpolated from, the sampling times are compared with the stored acceptable values for corresponding points of the process against a predetermined and relatively small threshold of discrepancy, whereby if only a few samples depart from the stored parameters without showing a trend, that is, there is overall conformity, the intermediate product is not rejected. Alternatively or additionally, each value of temperature and/or pressure monitored at a sampling time may be compared with stored acceptable values for a corresponding point of the process and any discrepancy in excess of a predetermined and relatively large threshold result in instant rejection; clearly these different forms of comparisons may be applied together. Furthermore such comparisons may follow different criteria and the parameters may be monitored on a continuous basis rather than by samples.

At the end of the setting-up interval, the control means releases the locking means, the ram means is retracted away from the bed and the now partially cured intermediate sheet is lifted from the bed of the press by way of the guidance plates and depending upon the result of the monitoring and comparisons undertaken by the control means, at least an indication is given whether or not the sheet is suited to be passed to the further free-baking operation or rejected.

The heated press bed and closure face are each treated with mould release agent if necessary and the cycle is repeated of disposing a green lining sheet in the recess and placing a preheated closure member thereon before applying sandwiching pressure.

Each intermediate lining sheet that is removed from the stabilising press, and is not considered a reject, has such strength as to be dimensionally stable both to handling forces and any internal forces resulting from continuation of the cross-linking process accelerated by elevated temperature.

Each such intermediate lining sheet 45 is placed in oven means 100 maintained at a temperature that is conventional for final curing of friction lining material based on thermosetting resin binders, in the range 240-300°C. The intermediat lining sheet, which has a comparatively low thermal mass and may still be hot from the stabilising press, is, absent the traditional carrier with its large thermal capacity or any additional means to effect constraint on the lining sheet, quickly able to absorb heat necessary to continue curing of the thermosetting

resins of the lining element sheet. Each intermediate lining sh et is held within the baking oven for said relatively short time interval of 20-60 minutes during which the additional degree of resin curing achieves the desired degree of hardness and mechanical strength required of a lining sheet for use in a brake shoe of a vehicle wheel. Clearly the degree of final curing by which desired physical properties can be achieved is open to variation by changing the precise duration of free baking in the oven and/or temperature of the oven.

The oven means 100, shown schematically in Figure 4, is a continuous oven having a curtained inlet region 101, to receive the bonded intermediate lining sheets, and transport means 102 in the form of a continuous conveyor belt on which the sheets are supported, operable to transport each sheet through the oven in a predetermined time interval and discharge it therefrom at a curtained outlet region 103. An alternative transport means, not shown is an overhead track or the like from which each sheet is suspended.

The resultant friction lining sheet 46 of thickness $T_I = (T_L + \delta_I T_L)$ is then of a form corresponding to one produced in much longer time by the conventional process and able to be dressed by the aforementioned machining of its thickness by $\delta_I T_L$, drilling, cutting etc.

It will be appreciated that notwithstanding the eight-to ten-fold reduction in time spent by each intermediate lining sheet in the oven means to obtain a commercially useful throughput from such oven means, dictates that a significant number of intermediate lining sheets are contained within the oven at any instant.

With some forms of transport system, such as an overhead conveyor from which the sheets hang, the track may follow a meandering path through the oven which the products enter and leave serially. In such a case the each intermediate sheet released from the stabilising press may be directly attached to this transport system, so that the throughput rate of the oven matches that of the stabilising press, subject of course to any rejects.

With other forms of transport system, such as conveyor belt, with which it is less easy to devise other than a direct route through the oven, it may be appropriate to have one or more stabilising presses 50 providing intermediate lining sheets at a rat greater than th cycle rate of an individual press as described abov . For xample, a plurality of stabilising presses may be set up and operated in parallel; this is economically feasible through the use of relatively inexpensive pneumatic ram means and the exceptionally low sandwiching pressure applied

thereby in the consolidation interval and simple configuration of press bed and guidance means.

Alternatively, a plurality of press beds may be movably disposable with respect to single ram means, different from that described above in that the locking means is arranged to lock the closure member directly with respect to the guide means, possibly manually, so that the ram can be retracted after the short consolidation interval and the bed moved for the duration of the setting-up interval whilst the ram means is employed in applying sandwiching pressure to a replacement bed.

Clearly there are a number of options available for performing the sandwiching operation throughout consolidation and setting-up intervals.

Within the consolidating interval the control means as described may admit gas to the pneumatic ram means such that the load the ram applies to the shoe body increases in any specified manner for the consolidating interval. The load may be caused to increase substantially linearly throughout the internal or follow some other law of continuously increase; it may also respond to back-pressure from within the lining element to modify the load vs. time relationship.

It will be appreciated that the duration of the setting-up interval may be chosen in response to time constraints imposed by other processes such that the cross-linking has not proceeded to a degree wherein the reaction pressure on the locking means has subsided to a level and for a duration that it is safe to release the locking means from the still-heated lining sheet without that sudden drop in pressure being significant in respect of creating gases and/or vapours in the thermosetting materials. In such circumstances, the control means may be arranged to cause the ram means to apply a sandwiching pressure equal to that monitored from the locking means and, after release of the locking means, ramp down the ram pressure as a function of time.

Alternatively, instead of determining a substantially fixed and implicitly conservative setting-up interval after which the level of reaction is certain to have fallen, the control means may, as a result of monitoring the reaction pressure level, determine in each case when the level has fallen to a consistently low value to terminate the setting-up interval on that basis.

From the above descriptions it will be appreciated that within certain constraints, usually temperature ranges associated with cross-linking behaviour of the thermosetting resin materials used in making friction lining materials, there is scope for variation of time intervals and some process steps in accordance with the specific materials employed and the physical parameters desired of the finished friction element. However, notwithstanding such minor variations, it will be appreciated that the initial cross-linking/stabilising phase undertaken in the stabilising press has a duration of about one minute, including loading and unloading, and the free baking of the dimensionally stabilised lining sheet takes only 60 minutes or less.

It is to be expected that friction elements having larger sizes of lining, particularly in thickness, require changes in durations and pressures and possibly temperatures to ensure that the larger volumes of gases trapped further from venting surfaces can be expelled properly and achieve a uniform density of lining and heat for cross-linking can penetrate to all parts of the lining sheet, to be in principle as described above.

whereas the above described manufacturing process is configured to materials which themselves, and as a result of the admixing and rolling into plastic form, have trapped gases and/or volatile materials and/or take part in chemical reactions (typically, but not necessarily, condensation reactions) during curing which gives rise to such gases, and for which the ability to vent such gases is essential, it will be appreciated however that the resin binder material may have a composition which cures without significant evolution of gases, but the method and apparatus as described above may still be employed.

Whereas the above descriptions have concentrated on the production of a friction lining sheet that is suitable after dressing for an arcuate brake shoe of which the friction lining is intended to bear against a cylindrical brake drum, it may also be employed, with modification only to the shape of the bed and closure members, to manufacture a substantially flat sheet, for brakes of other types such as for a disc brake pad, or clutch plate.

It will also be appreciated that the structure of the stabilising press may be varied from that described above whilst performing the same function. For example the bed of the press may be shaped to support the concave face of the green lining sheet.

It will be appreciated that although it is convenient to load and unload the stabilising press manually, the relatively simple operations may be performed by mechanical manipulation

means, co-ordinated with, or under the control of, the control means 90.

In particular such manipulation could be associated with automatically ejecting reject intermediate lining sheets from the process and preventing their reaching the oven means 100.

Other variations are possible, For example, the ram means may comprise a mechanical lead screw arrangement or a hydraulic piston and cylinder arrangement; in the latter case the locking means may operate by providing a hydraulic lock and the reaction pressure measured by way of monitoring pressures or pressure differentials within the hydraulic lock.

It will be appreciated that the extremely low consolidating pressure applied by the stabilising press is likely to be insufficient to effect significant redistribution of the material of the lining sheets whilst avoiding excessive extrusion. For example, if the press bed and closure member have radii of curvature that result in their floor and closure face respectively being other than parallel and the green lining sheet is of uniform thickness then the pressure is unlikely to permit more than a minor deviation in curvature of one or both of the major faces of the sheet by th press to achieve non-uniform thickness. However, the consolidating pressure itself, or a pre-consolidating or shaping pressure, may be applied by the ram means to enable the closure member to bend a substantially flat but plastic green lining sheet, supported at individual points by the profiled bed, into conformity with the bed and closure member prior to application of the consolidating pressure.

Furthermore, given that the lining sheet is formed by rolling, one or both major faces may be profiled by a pattern, of peaks and recesses that comprise a 'rough' finish for mechanical engagement of the cured lining or to ease cutting of the cured sheet, and corresponding profiles (recesses and peaks) may be provided at the surface of the press bed and/or the closure member whereby notwithstanding the absence of a smooth major surface, the sheet is abutted and supported in conformity with the whole surface.

It will be appreciated that the bed of the stabilising press may be formed other than by combination of shoulder and guidance plates and an intervening block. For instance, as illustrated in Figure 5(a), the shoulder of each guidance plate 56_1, 57_1 may be more extensiv such that they abut each other and obviate the separate block. Alternatively, as illustrated in Figure 5(b), the guidance plates 56_2, 57_2 may be formed without the above-described integral shoulders and the floor of the recessed bed be formed totally by the surface of a separate

block 60 as described above.

Furthermore, in any of the above-described configurations, the guidance plates may be separable from each other to facilitate removal of an intermediate lining sheet and, possibly, insertion of a green lining sheet. Such an embodiment may be particularly attractive in which the floor of the bed is split parallel to the guidance plates whereby the plates and bed parts can be moved apart to permit an intermediate lining sheet to drop from the stabilising press.

A recessed bed formed simply between the guidance plates and a floor joining them may result in the minor edges of the green lining sheet being enclosed by the guidance plate under consolidating pressures to the extent that, notwithstanding the absence of specific sealing that effects a venting path between the closure member and guidance plates, the gases evolved during the consolidating and setting-up intervals do not readily escape from the lining sheet and represent by the pressure thereof within the sheet, a possible cause of sheet rejection by the control means.

The recessed bed of the stabilising press may be formed as shown in the sectional elevation of Figure 5(c) with the surface 60' of block 10 displaced with respect to the shoulders 58, 59 of the guidance plates to such extent that a shallow recess 51', is formed in the floor of the bed of less depth than the thickness ($T_I+\delta T_I$) required of the intermediate lining sheet, but at least as extensive as the other dimensions so that the green lining sheet 40 can be received in it. When so received, as shown ghosted, the major face 41 of the green lining sheet opposite to that supported by the floor of the recess is without this recess, thereby exposing in part the minor surfaces 43 of the sheet spaced from the guidance plates by the width of the shoulders 58 and 59 and, notwithstanding any minor degree of extrusion of the lining material into the spaces as a result of the low consolidation pressure, provided a more efficient and certain escape route for gases vented during the consolidation and setting-up intervals.

In yet another variant of the stabilising press shown at 500 in Figure 5(d) the arrangement of Figure 5(b) is modified such that the member 501 with major surface 502 attached to the ram means includes spaced, depending guidance plates 503 and 504 which, in reciprocation, can surround an un-walled member 505 having surface 506, the members 501 and 505 being correspondingly flat or arcuate in a direction orthogonally to the plane of the Figure. This may be viewed as having the guidance plates coupled to closure member 501 rather than member 505 defining press bed 506; alternatively, this may be viewed as the member 501 defining

press bed 502 and the member 506 defining the closure member, that is, with the ram means arranged to move the press bed rather than closure member. It will be appreciated that as such reciprocal movement between press bed and closure member is relative, in any of the embodiments described and illustrated above, the ram means may undertake absolute movement of the press bed with respect to a 'fixed' closure member.

It will also be appreciated that when the press bed and closure member are correspondingly arcuate in one plane, it is possible for either one to be concave or convex, provided they are the substantially same as each other.

It will be appreciated that with the essentially vertical sandwiching motion and generally longitudinally extending press bed and closure member surface, it is most convenient to dispose the green lining sheet with respect to the press by placing it manually or mechanically with one major face thereof against the press bed (or closure member, depending on how defined). The stabilising press may be oriented such that the reciprocation of the ram means is essentially horizontal, that is, the plane of the lining sheet is substantially vertical. This may be implemented, as illustrated in stabilising press 600 in Figure 6, such that the green lining sheet 601 is placed between the horizontally planar guidance plates 602 and 603 by way of an aperture 604 in the upper one so that initially its major faces are in contact with neither the press bed 605 nor closure member 606. The ram means 607 may then be controlled to contact one face 608 of the green lining sheet 601 and displace it laterally and away from the aperture 604 fully between the guidance plates until its opposite major face 609 contacts the press bed 605.

The stabilising press as described above may be further modified in respect of the closure member. As illustrated in Figures 3(a) and (b) the closure member has the single surface 54, defined as the closure face, conforming to the arcuate shape of the press bed and is permanently coupled to the ram means, being retractable thereby to permit positioning of a green lining sheet and removal of the intermediate lining sheet. It will be appreciated that the closure member may be dismountable from the ram interface, or with the ram interface from the ram. It will be appreciated that such demountable closure member will lose heat unless it is coupled to the heating means; if it is not practicable to maintain the internal heating elements coupled permanently, the heating elements may be arranged to effect a rapid temperature increase and/or the heating means may comprise a separate preheating oven (indicated at 64' in Figure 2(a)) in which the closure member is disposed when not attached to the ram

int rface; such preheating oven could be a continuous oven as d scribe for oven means 100 and deliver pre-heated closure m mbers on a timed continuous basis synchronised to the pressing operation.

Not only the closure member, but also the press bed itself may be discrete from the source of heat, either being pre-heated in a remote oven or the like before use or mounted on a heated bed or hot-plate to receive heat therefrom by conduction.

Furthermore, although the above description has concentrated on the ability to rapidly define final dimensions by initially applying heat to at least the major faces of the lining sheet to commence a combined gentle moulding and setting-up of resin binder of the surface regions, it will be appreciated that if it is required by virtue of the lining sheet dimensions and/or materials to commence such consolidating and setting-up more slowly, and not 'over-cure' the surface regions to too great an extent in advance of deeper regions, then one of the press bed and closure member may be unheated above ambient temperature and the heat that complements the consolidating pressure be applied through one face only, or one or both bodies may be raised in temperature with the lining element in situ to effect such a said more progressive input of heat to the surface regions of the lining sheet.

In the embodiment variation described above with reference to Figure 5(c) it was discussed that provision be made for ensuring that venting could occur by way of at least parts of th minor surfaces of the lining sheet and between the closure member and guidance means.

In a further embodiment of stabilising press, indicated at 750 in Figure 7, the press differ from that 50 of Figure 3(a) (but like parts are given like references) in that the closure member 753 has, at its closure face 754 a surface perforated with an array of small holes 755 each sufficiently large to permit venting of gases from the major face of the lining sheet it abuts, but also sufficiently small to prevent extrusion of the friction material therethrough to the ext nt where it could (after setting-up) become mechanically interlocked with the closure face and inhibit separation and/or form a disruption to the material that extends within its bulk. It is to be expected that such closure face would result in a major face of the cured lining sheet having an array of shallow peaks readily removed by subsequent dr ssing as mentioned above, or left in place to assist subsequent seeing of th sheet in a brak .

The perforated closure face may be formed, as illustrated, in a sheet 756 which overlies a

plenum chamber 757 vented to the atmosphere by way of through-apertures 758 in the closure member body, or (not shown) be formed by apertures which extend individually through the closure member may of course be formed if appropriate in side walls of the closure member and/or stabilising press bed or guide plates.

CLAIMS

1. A method of manufacturing a friction lining sheet comprising
(1) producing a plastic, green friction lining sheet, including fibrous and/or filamentary reinforcement and friction modifying materials in an uncured thermosetting binder matrix, below a setting-up temperature required to initiate cross-linking of the binder matrix and disposed between opposite major faces defining the sheet thickness,
(2) disposing the green lining sheet in a stabilising press, having a bed conforming substantially to the shape and dimensions required of a major face of the lining sheet, sandwiching it between the bed and a non-sealing closure member, corresponding to the shape required of the opposite major face of the lining sheet, at least one of said bed and closure members being heated to a temperature in excess of said setting-up temperature,
(3) applying to the sandwiched green lining sheet, by way of the closure member and bed, a consolidating pressure increasing over a predetermined consolidation interval from substantially zero to a predetermined level permitting plastic flow of the sheet into conformity with the recessed bed and closure member but without significant extrusion before onset of cross-linking of the thermosetting resin binder, and thereafter maintaining the separation between member and bed achieved at the end of the consolidation interval for a setting-up interval to permit cross-linking adjacent the heated surfaces to define a partially cured, dimensionally stabilised intermediate lining sheet having the final dimensions of the lining,
(4) removing the bonded intermediate lining sheet from the stabilising press and
(5) baking the intermediate lining sheet unconstrained at a predetermined baking temperature in excess of said setting-up temperature and for a baking interval to effect further curing of the thermosetting resin of the dimensionally defined lining sheet to a predetermined level of hardness and strength.

2. A method as claimed in claim 1 comprising disposing the green lining sheet with one major face against the bed and guiding the closure member towards the bed to bear against th opposite major face of the lining sheet.

3. A m thod as claimed in claim 1 or claim 2 comprising h ating th closure member to a

temperature in the range 180-250°C immediately prior to sandwiching the green lining sheet between the closure m mber and bed of the stabilising press.

4. A method as claimed in any one of claims 1 to 3 comprising maintaining the bed of th stabilising press at a temperature in the range 200°C to 250°C.

5. A method as claimed in any one of claims 1 to 4 comprising increasing said consolidating pressure to said predetermined level in the range 35-150 kN/m^2 (5-21.75 psi) over a consolidating interval in the range 4-6 seconds.

6. A method as claimed in claim 5 comprising maintaining the separation between closure member and bed achieved at the end of the consolidating interval for a setting-up interval of in the range 40-120 seconds.

7. A method as claimed in any one of claims 1 to 6 comprising monitoring the pressure within the lining element in the press sandwiched between platform and press bed throughout the consolidating and setting-up intervals.

8. A method as claimed in claim 7 comprising determining when the monitored lining element pressure has reached a stable predetermined low value to indicate an end of the setting-up interval.

9. A method as claimed in claim 7 or claim 8 comprising (a) storing parameters relating to suitable pressure values within the lining sheet as a function of time through th consolidating and setting-up intervals that are known to result in a friction lining having desired physical properties, (b) monitoring continuously the pressure exerted on the green lining sheet during the consolidating interval and reaction pressure exerted by the lining sheet during the setting up interval, (c) comparing the monitored and stored values and (d) providing, in response to a predetermined degree of deviation between the values, an indication that the bonded intermediate product is unsatisfactory and a reject.

10. A method as claimed in any one of claims 1 to 9 comprising baking the intermediate lining sheet at a temperature in the range 240-300°C for a baking interval in the range 20-60 minutes.

11. A method as claimed in any one of claims 1 to 10 comprising producing said green lining sheet having a density in the range of 80% to 95% of the density required of the lining and a volume correspondingly greater than required of the lining.

12. A method as claimed in claim any one of claims 1 to 11 comprising producing said green lining sheet by rolling to effect said major faces by contact with rolling surfaces and alignment of said reinforcement with said major faces.

13. A method as claimed in any one of claims 1 to 13 comprising forming said green lining sheet as an elongate slab and deforming said slab between its ends into a substantially cylindrically arcuate shape conforming to a cylindrically arcuate platform of a brake shoe for which intended.

14. A method as claimed in claim 13 comprising deforming said slab by passage between curling rollers.

15. A method of manufacturing a friction lining, substantially as herein described with reference to the accompanying drawings.

16. An arrangement for producing a friction lining comprising fibrous and/or filamentary reinforcement and friction modifying materials in a thermosetting binder matrix between one major face of the element and an opposite one defining its thickness, the arrangement comprising

a) formulating means, operable to produce a green friction lining sheet, in which the thermosetting binder matrix is uncured and below a setting-up temperature at which cross-linking thereof is initiated,

b) a stabilising press including

1) a bed shaped substantially corresponding to the shape required of said one face of the lining sheet and dimensioned to receive a said green lining sheet with said one major face thereof against the bed,

2) a non-sealing closure member having a closure face corresponding to the shape required of the opposite major face of th lining sheet,

3) guidance means extending away from the bed and operable to support said closure member overlying the bed with the closure face directed thereto and

ffect guidance between the closure member and the bed in a direction towards and away from the bed,

4) heating means operable to heat at least one of the bed and the closure member to above said setting-up temperature for the lining element,

5) ram means, having relatively displaceable parts fixed and movable respectively with respect to the bed, operable to drive the closure member and bed towards each other,

6) locking means operable to retain the closure member in position with respect to the bed, and

7) control means operable

(i) to cause the ram means to move the closure member to sandwich the green friction lining sheet between the closure face and the bed,

(ii) to cause the ram means to apply a force between the closure member and bed increasing between predetermined levels in a predetermined consolidating interval, sufficient to force the materials of the lining sheet into conformity with the closure member and bed without significant extrusion of unconfined materials, prior to significant cross-linking of the thermosetting binder matrix due to heat and pressure applied to the surface regions,

(iii) to initiate operation of the locking means to lock the closure member in position with respect to the bed at the end of said consolidating interval for a setting-up interval in which said surface regions achieve by continued cross-linking structural strength in excess of internally generated forces resulting from the cross-linking and heating, and

(iv) to initiate release of the locking means at the end of said setting-up interval to permit the intermediate lining sheet of partially cured, dimensionally stable friction lining material to be removed from the press, and

c) oven means operable to receive said intermediate lining sheet unconfined at a predetermined baking temperature in excess of said setting-up temperature for a predetermined baking interval to effect additional cross-linking of the thermosetting components thereof to cure the friction lining to a predefined condition of hardness and physical strength.

17. An arrangement as claimed in claim 16 in which both of the bed and closure member

are preh ated to a temperature in excess of said setting-up temperature of the lining element.

18. An arrangement as claimed in claim 16 or claim 17 in which the stabilising press comprises a pair of guidance plates, operably spaced apart by an operable datum separation corresponding to the width of the closure member such that the closure member can slide non-sealingly between facing surfaces thereof defining said guidance means, and defining the edges of the bed of the press.

19. An arrangement as claimed in any one of claims 16 to 18 in which the stabilising press comprises a pair of guidance plates spaced apart such that the closure member can slide between them and defining the edges of the bed of the press, and the closure member includes at least one through-aperture extending to the closure face and at the closure face an array of venting apertures in communication with each said through-aperture of such dimensions as to permit the lining element to vent by way of said closure member during curing of the resin binder but without the material extending through any venting aperture to form a mechanical interlock therewith.

20. An arrangement as claimed in claim 18 or claim 19 in which the guidance plates operably fixed to, and define with, the bed a bed recessed for receipt and containment of said green lining sheet.

21. An arrangement as claimed in claim 20 in which each guidance plate of the pair has a shoulder extending from a face thereof towards the facing plate defining therebetween said recessed bed.

22. An arrangement as claimed in claim 21 in which said shoulders are separated by a spacing block the surface of which define with said shoulders said recessed bed.

23. An arrangement as claimed in any one of claims 18 to 22 in which the guidance plates defining the guidance means and the bed of the press are separable further than said operable datum separation to permit removal of th int rmediat lining sheet.

24. An arrangement as claimed in any one of claims 16 to 23 in which said heating means of the press comprises at least one heating element disposed within said press bed

and operable to supply heat to, and defin a temperature for, the surface thereof.

25. An arrangement as claimed in any one of claims 16 to 24 in which the closure member is removable from the guidance means and arranged to be disposed therein after disposition of the green lining element with respect to the bed by way of the guidance means.

26. An arrangement as claimed in claim 25 in which the heating means includes a preheating oven separate from the stabilising press operable to preheat the closure member and/or press bed prior to their disposition with respect to each other.

27. An arrangement as claimed in any one of claims 18 to 26 in which said bed comprises raised portions spaced apart in a direction parallel to the planes of the guidance plates and defining the ends of the recessed bed and minimum thickness of intermediate lining sheet.

28. An arrangement as claimed in any one of claims 16 to 27 in which the locking means comprises means to lock the movable part of the ram means in position with respect to the press bed.

29. An arrangement as claimed in claim 28 in which the ram means comprises a piston and cylinder arrangement and a source of pressurised fluid for the cylinder to displace the piston with respect thereto and arranged to exert a pressure on the closure member of less than 150 kN/m^2 (21.75 psi).

30. An arrangement as claimed in claim 28 or claim 29 in which the pressurised fluid is a liquid and said locking means comprises a hydraulic lock applied to the piston and cylinder arrangement.

31. An arrangement as claimed in claim 28 or claim 29 in which the ram means is a pneumatic ram.

32. An arrangement as claimed in any one of claims 16 to 31 in which the control means is (a) operable to store parameters relating to suitable pressure values within the lining sheet as a function of time through the consolidating and setting-up intervals that are

known to result in a friction lining having desired physical properties, (b) operable to monitor the pressure x rted on the lining sheet during the consolidating interval and reaction pressure exerted by the lining element during the setting up interval, (c) operable to compare the monitored and stored values and, (d) operable, in response to a predetermined degree of deviation between the values, to provide an indication that the bonded intermediate product is unsatisfactory and a reject.

33. An arrangement as claimed in claim 28 when dependant on claim 28 in which the control means includes load cell means operable to provide signals representative of the instantaneous load exerted on the actuated locking means by the reaction pressure from the lining sheet.

34. An arrangement as claimed in claim 32 or claim 33 in which the control means is responsive to a said indication to effect ejection of a reject intermediate lining sheet from the manufacture prior to receipt by said oven means.

35. An arrangement as claimed in any one of claims 16 to 34 in which the oven means comprises a continuous oven having an inlet region, operable to receive said intermediate lining sheet, transport means operable to transport the intermediate lining sheet through the oven in a predetermined time interval and to discharge it therefrom by way of an outlet region.

36. An arrangement as claimed in claim 35 in which the transport means comprises a travelling belt or overhead conveyor arranged to support the intermediate lining sheet unconstrained thereon for said passage through the oven.

37. An arrangement for producing a friction lining sheet the arrangement being substantially as herein described with reference to Figures 2(a) to 4 or any one of Figure 5(a) to 7 of the accompanying drawings.

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Claims searched: 1-15

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Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P): B5A(AA1, AA2, AA3, AT1P, AT9P)

Int Cl (Ed.6): B29C(43/00, 43/02, 43/56, 69/00, 69/02); F16D(69/00, 69/02, 69/04)

Other: Online:WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB2195944A	Toyota Jidosha KK	
A	GB2012204A	Hooker Chemicals	
A	GB1350268A	Abex Corpn	
A	WO94/27059	GB Tools & Components	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		